




Test report No:

NIE: 48847REM.001A1

Partial Test report (Modification 1)
FCC Rules and Regulations 47 CFR Chapter I Part 15 Subpart B (10-01-14 Edition)
& ICES-003 ISSUE 5 (2012)

Identification of item tested.....:	Wireless sensor node for the Internet of Things
Trademark	Libelium
Model and /or type reference.....:	Waspmote Plug & Sense! LoRaWAN US
Other identification of the product	S/N: Prototype
Final HW version	1.0
Final SW version	1.0
FCC ID	Chipset's FCC ID: T9JRN2903 Libelium's product FCC ID: XKM-WPS-LORA-V1
IC	Chipset's IC: 6514A-RN2903 Libelium's product IC: 8472A-WPSLORAV1
IMEI TAC	N/A
Features	Can communicate with LoRaWAN networks. USA and Canada version. Contains an RN2903 chipset.
Manufacturer.....:	LIBELIUM COMUNICACIONES DISTRIBUIDAS, S.L. C/ Escatrón 16 (Edificio Libelium), C.P.: 50014. Zaragoza. Spain.
Test method requested, standard.....:	FCC Rules and Regulations 47 CFR Chapter I Part 15 Subpart B (10-01-14 Edition) & ICES-003 ISSUE 5 (2012)
Summary	IN COMPLIANCE
Approved by (name / position & signature).....:	Rafael López EMC LAB Manager  Firmado digitalmente por RAFAEL LÓPEZ MARTÍN Fecha: 2016.08.29 11:52:13 +02'00'
Date of issue.....:	2016-08-29
Report template No.....:	FDT11_18

Index

Competences and guarantees.....	3
General conditions.....	3
Uncertainty	3
Usage of samples.....	4
Test sample description	4
Identification of the client	4
Testing period.....	4
Environmental conditions.....	5
Modifications to the reference test report.....	6
Remarks and comments.....	6
Testing verdicts (Legend).....	6
List of equipment used during the test.....	6
Appendix A – Test result.....	7
Appendix B - Photographs	17

Competences and guarantees

AT4 wireless is a testing laboratory accredited by the National Accreditation Body (ENAC - Entidad Nacional de Acreditación), to perform the tests indicated in the Certificate No. 51/LE 147.

This certificate of conformity was issued in accordance with the decision Nº 3/2000 of the Joint Committee established under the Agreement on Mutual Recognition between the European Community and the United States of America. By this decision, AT4 wireless can act as Conformity Assessment Body (CAB) on Electromagnetic Compatibility. This Certificate applies to the samples listed at technical reports.

This laboratory is designed by the Federal Communications Commission (ES0004)

AT4 wireless is a testing laboratory competent to carry out the tests described in this report.

In order to assure the traceability to other national and international laboratories, AT4 wireless has a calibration and maintenance program for its measurement equipment.

AT4 wireless guarantees the reliability of the data presented in this report, which is the result of the measurements and the tests performed to the item under test on the date and under the conditions stated on the report and, it is based on the knowledge and technical facilities available at AT4 wireless at the time of performance of the test.

AT4 wireless is liable to the client for the maintenance of the confidentiality of all information related to the item under test and the results of the test.

The results presented in this Test Report apply only to the particular item under test established in this document.

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General conditions

1. This report is only referred to the item that has undergone the test.
2. This report does not constitute or imply on its own an approval of the product by the Certification Bodies or competent Authorities.
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4. This test report cannot be used partially or in full for publicity and/or promotional purposes without previous written permission of AT4 wireless and the Accreditation Bodies.

Uncertainty

Uncertainty (factor $k=2$) was calculated according to the AT4 wireless internal document PODT000.

Usage of samples

Samples under test have been selected by: The client.

Sample S/01 is composed of the following elements:

Control N°	Description	Model	Serial number	Reception date
48847B/001	Module LoraWan 900MHz	RN2903	---	2016-02-02
48847B/002	900MHz Antenna	RN2903	---	2016-02-02
45355E/011	Sensor node with wireless communication	Waspote Plug & Sense! LoRaWAN US	11	2015-10-26
45355E/068	Luminosity probe	Plug&Sense	---	2015-10-26
45355E/184	Dummy battery connector	---	---	2016-02-01

Sample S/01 incorporates a MURATA ferrite with the code BLM21AG601SN1 in the clock input; It was added another ferrite with the same code to the clock output and two 50nF capacitors, one on the DC/DC input and another one in the output; It was added a toroidal ferrite with the code WÜRTH 742 70 13 with two turns on the power supply cable. It was reduced the load current with R43 at 3.3K. It was added a ferrite with the code WÜRTH 7427503 in the positive load cable and it was replaced C15 to 22µF and it was added a 330µF capacitor in the DC power supply cable. A ferrite WE 742 712 22 is placed on the 6Vdc cable (3 turns).

Test sample description

This device receives data from sensors and sends information with its wireless radio. It is battery powered and can be easily programmed.

Identification of the client

LIBELIUM COMUNICACIONES DISTRIBUIDAS, S.L.

C/ Escatrón 16 (Edificio Libelium), C.P.: 50014. Zaragoza. Spain.

Testing period

The performed test started on 2016-02-03 and finished on the same day.

The tests have been performed at AT4 wireless.

Environmental conditions

In the control chamber, the following limits were not exceeded during the test:

Temperature	Min. = 15 °C Max. = 30 °C
Relative humidity	Min. = 45 % Max. = 60 %
Shielding effectiveness	> 100 dB
Reference resistance to earth	< 1 Ω

In the semianechoic chamber, the following limits were not exceeded during the test.

Temperature	Min. = 15 °C Max. = 30 °C
Relative humidity	Min. = 45 % Max. = 60 %
Air pressure	Min. = 860 mbar Max. = 1060 mbar
Shielding effectiveness	> 100 dB
Reference resistance to earth	< 1 Ω
Normal site attenuation (NSA)	< ± 4 dB at 10 m & 3m distance between item under test and receiver antenna, (30 MHz to 1000 MHz)
Site VSWR	< ± 6 dB at 3m distance between item under test and receiver antenna, (1 GHz to 18 GHz)
Field homogeneity	More than 75% of illuminated surface is between 0 and 6 dB (26 MHz to 18 GHz).

In the chamber for conducted measurements, the following limits were not exceeded during the test:

Temperature	Min. = 15 °C Max. = 30 °C
Relative humidity	Min. = 45 % Max. = 60 %
Air pressure	Min. = 860 mbar Max. = 1060 mbar
Shielding effectiveness	> 100 dB
Reference resistance to earth	< 1 Ω

Modifications to the reference test report

It was introduced the following modifications in respect to the test report number 48847REM.001 related with the same samples, in the next clauses and sub-clauses:

It was modified a typo in the IC code of the page 1.

This modification test report cancels and replaces the test report 48847REM.001.

Remarks and comments

The tests have been realized by the technical personnel: José Manuel Márquez.

The total uncertainty of the measurement system for the measured radio disturbance characteristics of EUT from 150 kHz to 30 MHz is $I = \pm 3,60$ dB for quasi-peak measurements, $I = \pm 3,48$ dB for peak measurements ($k = 2$).

The total uncertainty of the measurement system for the measured radio disturbance characteristics of EUT from 30 MHz to 1 GHz is $I = \pm 4,57$ dB for quasi-peak measurements, $I = \pm 4,48$ dB for peak measurements ($k = 2$) and from 1 to 12,75 GHz is $I = \pm 3,43$ dB for average and peak measurements.

The total uncertainty of the measurement system for the measured radio disturbance characteristics of EUT from 12,75 GHz to 26 GHz is $I = \pm 4,09$ dB for average and peak measurements.

The conducted emission test does not apply according to the standard on DC power supply.

The operation mode used has been chosen as a worst case mode.

Testing verdicts (Legend)

Not applicable	N/A
Pass	P
Fail	F
Not measured	N/M

List of equipment used during the test

CONTROL NUMBER	DESCRIPTION	MANUFACTURER	MODEL	LAST CALIBRATION	NEXT CALIBRATION
1999	EMI Receptor	ROHDE & SCHWARZ	ESIB 26	2015-06-16	2017-06-16
2932	Bilog Hybrid Antenna	SUNOL	JB6	2014-05-11	2017-05-11
4612	Horn Antenna	SCHWARZBECK MESS- ELEKTRONIK	BBHA 9120D	2013-12-29	2016-12-29
4658	RF Amplifier	SCHWARZBECK	BBV9743	2015-03-19	2016-03-19
4662	Transient limiter	SCHWARZBECK	VTSD 9561-D	2014-02-12	2016-02-12
4659	RF Amplifier	SCHWARZBECK	BBV 9718	2015-09-29	2016-09-29
4729	RF Amplifier	BONN ELEKTRONIK	BLMA 1840-1M	2015-12-02	2017-12-02
3545	Temperature and humidity probe	PICO TECHNOLOGY	HUMIDIPROBE	2015-03-04	2016-03-04
3556	Digital termohigrometer	T&D	TR-72W	2015-04-16	2016-04-16
4657	Horn Antenna	SCHWARZBECK	BBHA 9170	2014-03-28	2017-03-28
0224	Artificial network	ROHDE & SCHWARZ	ESH2-Z5	2015-02-06	2017-02-06

Appendix A – Test result

APPENDIX A CONTENT:

DESCRIPTION OF THE OPERATION MODES.....	9
RADIATED EMISSION. ELECTROMAGNETIC FIELD MEASURE.	10

DESCRIPTION OF THE OPERATION MODES

The operation modes described in this paragraph constitute a functionality of the sample under test for itself. Every operation mode takes a failure criteria for the immunity test that they were applying to it and a monitoring to guarantee performance of the same ones.

In the following table appears the operation modes used by the samples tested to that it refers the present test report.

OPERATION MODE	DESCRIPTION
OM#01	EUT ON. IDLE mode 900MHz LoraWan. Charging battery. Power supply: 6Vdc.

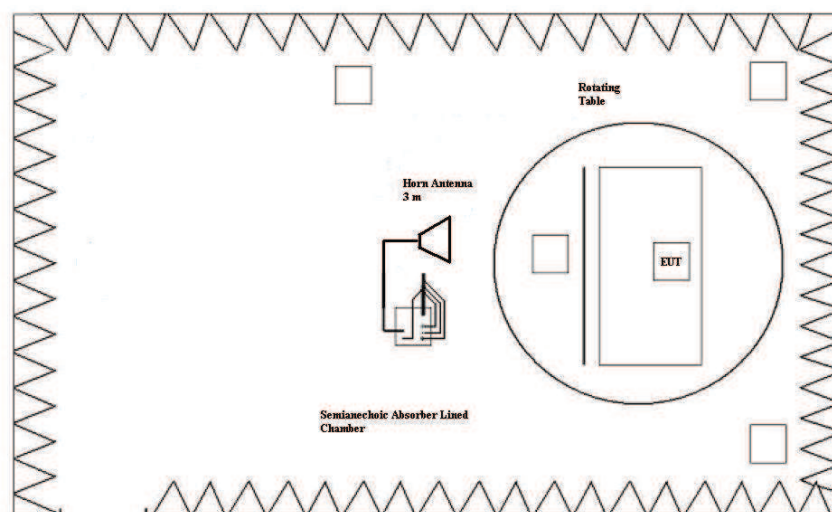
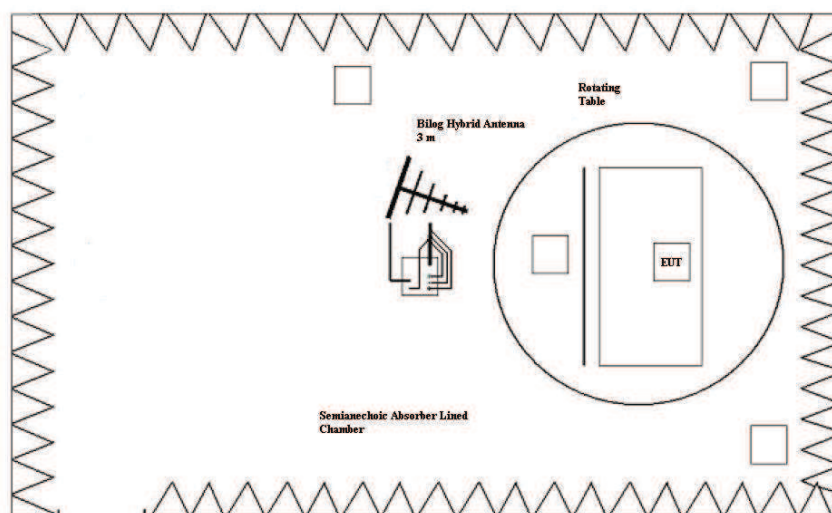
RADIATED EMISSION. ELECTROMAGNETIC FIELD MEASURE.

LIMITS:	Product standard:	FCC RULES AND REGULATIONS 47 CFR PART 15, SUBPART B (10-01-14 Edition) & ICES-003 ISSUE 5 (2012)
	Test standard:	FCC RULES AND REGULATIONS 47 CFR PART 15, SUBPART B (10-01-14 Edition) & ICES-003 ISSUE 5 (2012)

LIMITS OF INTERFERENCE CLASS B

The applied limit for radiated emissions, 3 m distance, according with the requirements of FCC Rules and Regulations 47 CFR Part 15.109, Subpart B (10-01-14 Edition) & ICES-003 ISSUE 5 (2012) in the frequency range 30 MHz to 26 GHz, for Class B equipment, which is a transmitter in a band over 500 MHz, was:

Frequency range (MHz)	QP Limit for 3 m ($\mu\text{V/m}$)	QP Limit for 3 m ($\text{dB}\mu\text{V/m}$)
30 to 88	100	40
88 to 216	150	43.52
216 to 960	200	46.02
Above 960	500	53.98
Above 1000	Limit for 3m AVG	Limit for 3m PK
	53.98 $\text{dB}\mu\text{V/m}$	73.98 $\text{dB}\mu\text{V/m}$



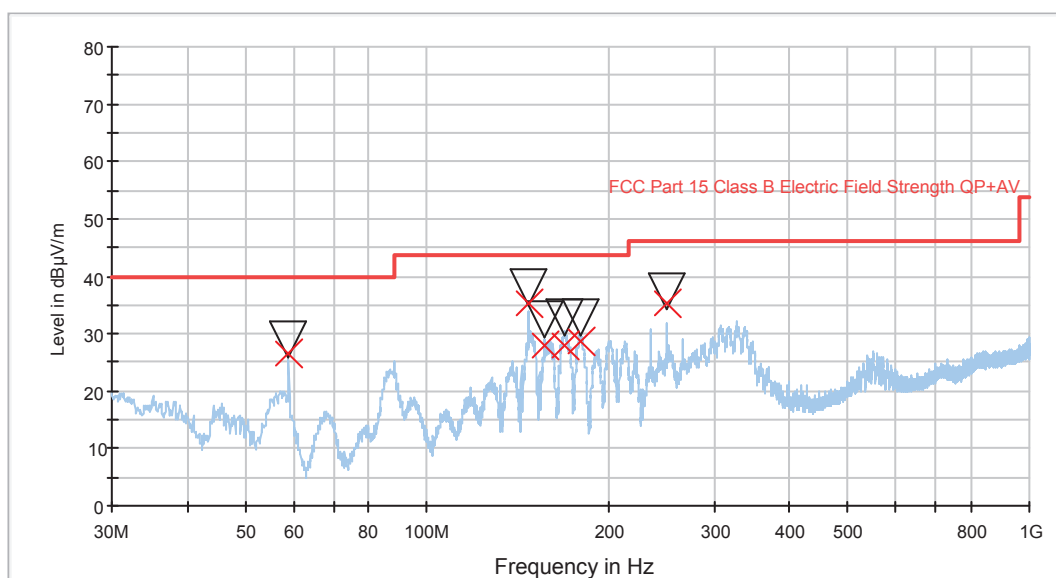
TESTED SAMPLES:	S/01
TESTED OPERATION MODES:	OM#01
TEST RESULTS :	CRmmnnxxyy: CR, Radiation Condition; mm: Sample number; nn: Operation mode ; xx: Measured range; yy: Polarisation.

CRmmnnxxyy	Description	Result
CR0101_RB	Range 30-1000 MHz.	P
CR0101_RA1_PH	Range 1-18 GHz. Horizontal pol.	P
CR0101_RA1_PV	Range 1-18 GHz. Vertical pol.	P
CR0101_RA2_PH	Range 18-26 GHz. Horizontal pol.	P
CR0101_RA2_PV	Range 18-26 GHz. Vertical pol.	P

Radiated Emission: CR0101_RB (30MHz to 1GHz)

Project: 48847REM.001
Company: Libelium
Sample: S/01
Operation mode: OM#01
Description: EUT ON. IDLE Mode 900MHz LoraWan. Charging battery. Power supply: 6 Vdc.

FCC class B



— FCC Part 15 Class B Electric Field Strength QP+AV
▽ MaxPeak
— Preview Result 1-PK+ QuasiPeak
×

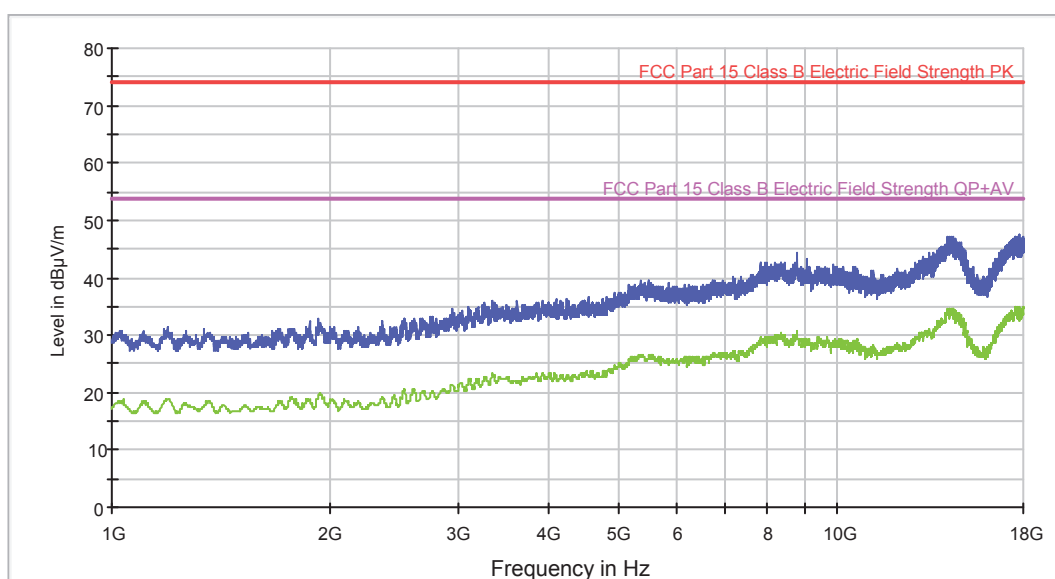
Maximizations

Frequency (MHz)	MaxPeak (dBµV/m)	QuasiPeak (dBµV/m)	Height (cm)	Polarization	Azimuth (deg)
58.988978	28.9	26.6	98.0	V	235.0
147.469138	38.1	35.3	208.0	H	250.0
156.422044	32.3	28.1	181.0	H	50.0
169.442285	32.7	28.1	141.0	H	204.0
179.631263	33.0	28.5	140.0	H	38.0
250.650902	37.4	35.2	122.0	H	174.0

Radiated Emission: CR0101_RA1_PH (1 – 18 GHz)

Project: 48847REM.001
Company: Libelium
Sample: S/01
Operation mode: OM#01
Description: EUT ON. IDLE Mode 900MHz LoraWan. Charging battery. Power supply: 6 Vdc. Horizontal polarization.

FCC 1-18GHz class B



— MaxPeak-ClearWrite-PK+ — Average-ClearWrite-AVG
— FCC Part 15 Class B Electric Field Strength PK — FCC Part 15 Class B Electric Field Strength QP+AV

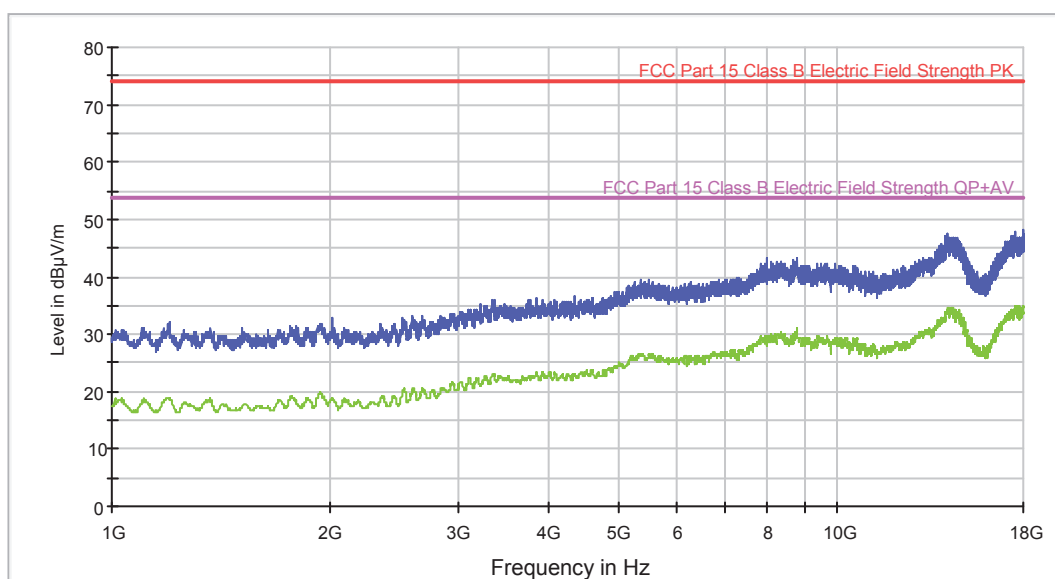
Subrange Maxima

Frequency (MHz)	MaxPeak-ClearWrite (dBµV/m)	Average-ClearWrite (dBµV/m)
1194.000000	31.4	18.8
1697.000000	31.2	18.3
1925.000000	32.7	19.6
3105.000000	35.0	22.2
4084.000000	36.2	23.2
5501.000000	39.5	26.4
7328.000000	40.3	26.8
8778.000000	44.3	30.8
13313.000000	44.4	30.6
17743.000000	47.5	34.7

Radiated Emission: CR0101_RA1_PV (1 – 18 GHz)

Project: 48847REM.001
Company: Libelium
Sample: S/01
Operation mode: OM#01
Description: EUT ON. IDLE Mode 900MHz LoraWan. Charging battery. Power supply: 6 Vdc. Vertical polarization.

FCC 1-18GHz class B



— MaxPeak-ClearWrite-PK+ — Average-ClearWrite-AVG
— FCC Part 15 Class B Electric Field Strength PK — FCC Part 15 Class B Electric Field Strength QP+AV

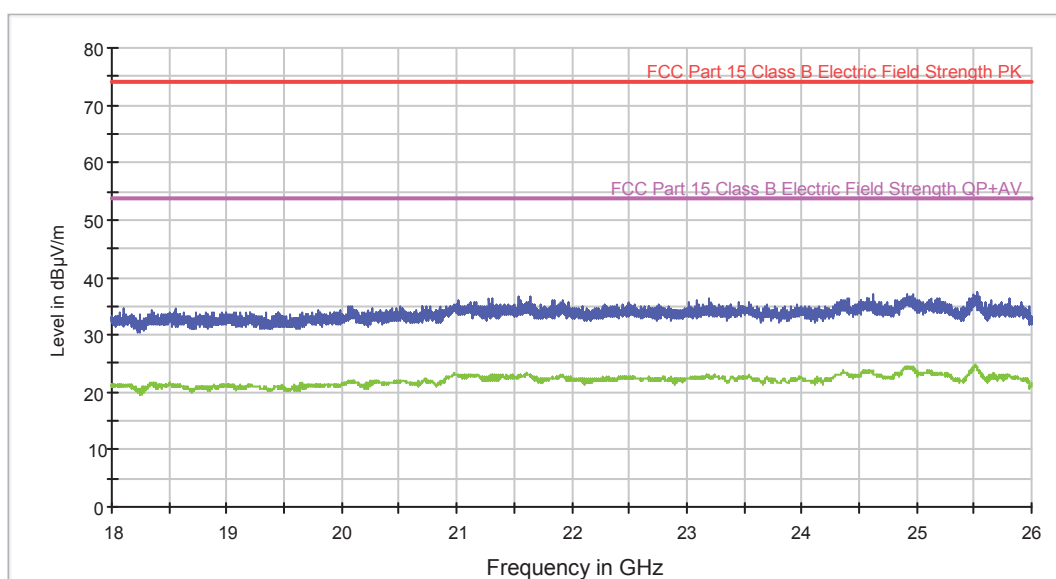
Subrange Maxima

Frequency (MHz)	MaxPeak-ClearWrite (dBμV/m)	Average-ClearWrite (dBμV/m)
1202.000000	32.1	18.7
1761.000000	31.5	18.9
2006.000000	32.8	18.7
3110.000000	34.4	22.3
3850.000000	36.4	23.3
5501.000000	39.5	26.3
7556.000000	40.2	27.6
8772.000000	43.3	30.7
13376.000000	43.4	30.2
17993.000000	48.1	35.0

Radiated Emission: CR0101_RA2_PH (18 – 26 GHz)

Project: 48847REM.001
Company: Libelium
Sample: S/01
Operation mode: OM#01
Description: EUT ON. IDLE Mode 900MHz LoraWan. Charging battery. Power supply: 6 Vdc. Horizontal polarization.

FCC 18-26GHz class B



— MaxPeak-ClearWrite-PK+ — Average-ClearWrite-AVG
— FCC Part 15 Class B Electric Field Strength PK — FCC Part 15 Class B Electric Field Strength QP+AV

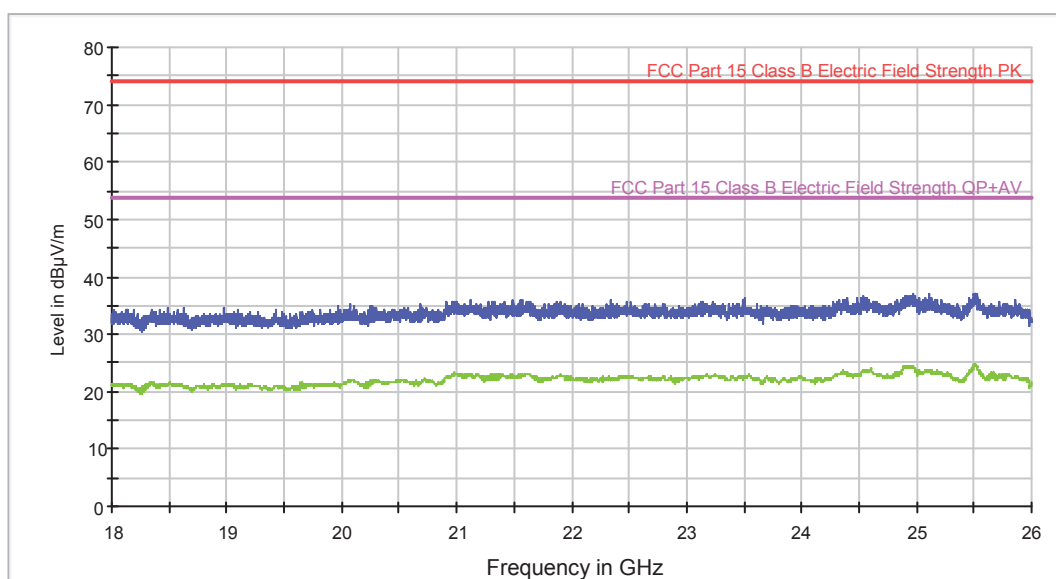
Subrange Maxima

Frequency (MHz)	MaxPeak-ClearWrite (dBµV/m)	Average-ClearWrite (dBµV/m)
18550.000000	34.5	21.2
19199.000000	34.0	21.2
20060.000000	35.0	21.8
20734.000000	35.0	22.1
21541.000000	36.5	22.8
21643.000000	36.5	22.7
23193.000000	36.3	22.8
23453.000000	35.7	22.6
24965.000000	37.2	24.2
25530.000000	37.2	24.3

Radiated Emission: CR0101_RA2_PV (18 – 26 GHz)

Project: 48847REM.001
Company: Libelium
Sample: S/01
Operation mode: OM#01
Description: EUT ON. IDLE Mode 900MHz LoraWan. Charging battery. Power supply: 6 Vdc. Vertical polarization.

FCC 18-26GHz class B



— MaxPeak-ClearWrite-PK+ — Average-ClearWrite-AVG
— FCC Part 15 Class B Electric Field Strength PK — FCC Part 15 Class B Electric Field Strength QP+AV

Subrange Maxima

Frequency (MHz)	MaxPeak-ClearWrite (dBμV/m)	Average-ClearWrite (dBμV/m)
18485.000000	34.7	21.1
18972.000000	34.7	21.3
20070.000000	35.2	21.9
20688.000000	35.3	21.4
21494.000000	36.0	22.7
22336.000000	35.8	22.1
23222.000000	35.7	22.7
23502.000000	36.4	22.4
24968.000000	37.2	24.2
25503.000000	37.2	24.6